Fall Semester 2004
Part 12

S·P·A·C·E TOURISM II™

Lecture Series given by Dr.-Ing. Robert Alexander Goehlich

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- Part 12: NASA and U.S. Industry: Space Tourism and Beyond -

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Content

- **General**
- **Guest Speaker: Mr. A.C. Charania, Senior Futurist, SpaceWorks Engineering Inc., USA**

Note: The following slides were provided courtesy of Mr. A.C. Charania

- **Requests from Audience for Lectures**

SpaceWorks Engineering, Inc. (SEI)

Recent Developments in Space Commercialization from Industry and NASA: Tourism and Beyond

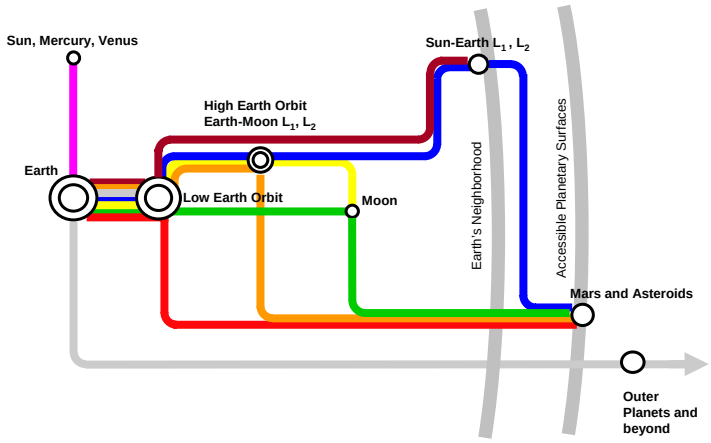
Revision A
08 December 2004

Senior Futurist:
Mr. A.C. Charania

SpaceWorks Engineering, Inc.

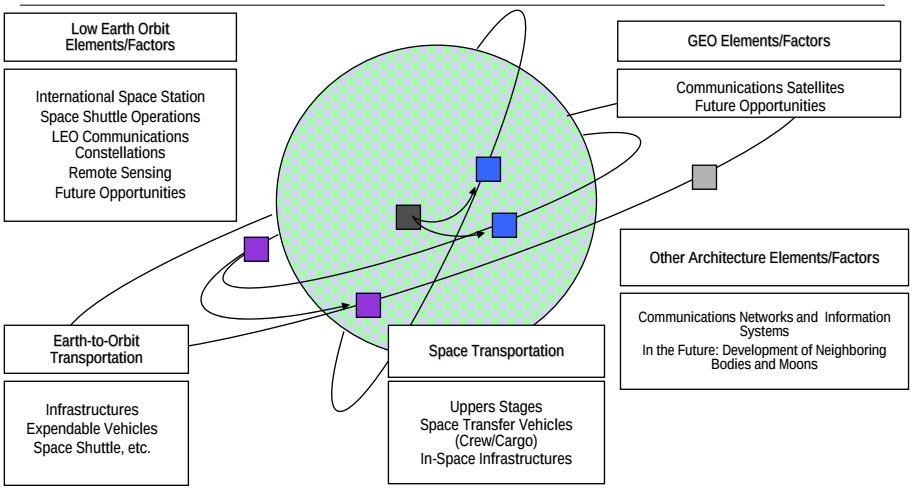
Perspectives on the Problem

Destinations: Transportation Links and Infrastructure Segments

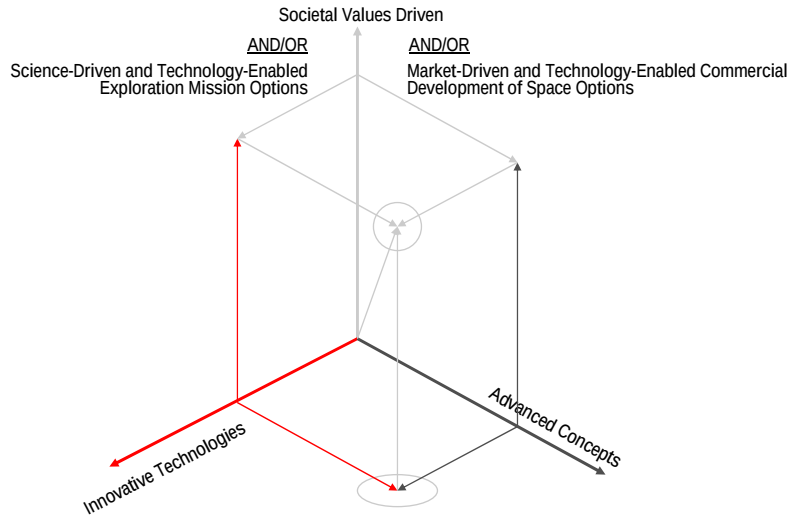


Base Image source: Gary L. Martin, Space Architect, National Aeronautics and Space Administration, "NASA's Strategy for Human and Robotic Exploration", June 10, 2003

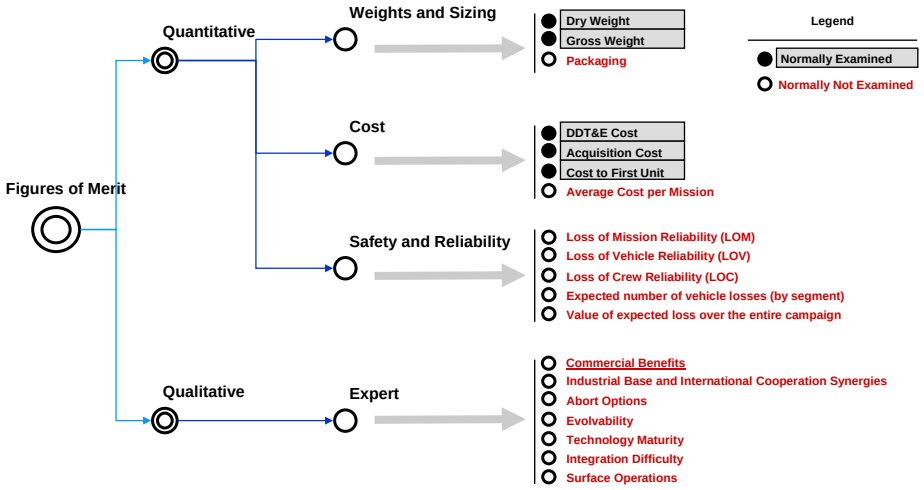
Elements of Space Exploration



Perspectives on the Challenge of Exploration

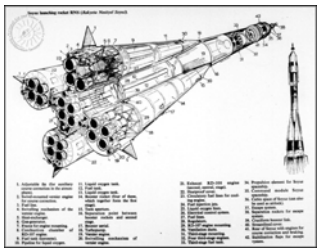


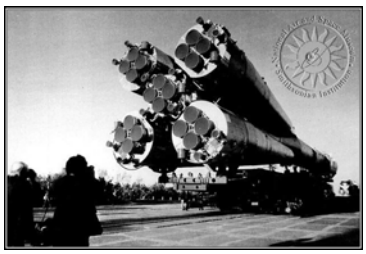
What Defines Value? Sample Figures of Merit (FOMs)



The Current Situation

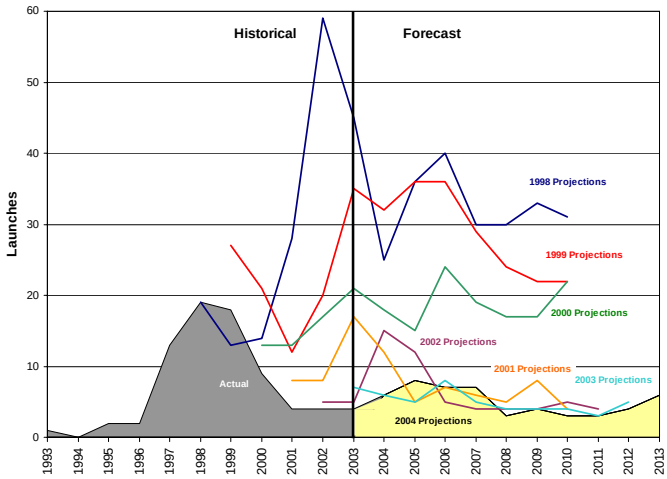
Current Launch Capabilities








Historical and Forecast Launch Comparison: LEO Cargo



Source: Sloan, John, "2004 Commercial Space Transportation Forecast for Non-Geosynchronous Orbits (NGSO)", Federal Aviation Administration Associate Administrator for Commercial Space Transportation (FAA/AST), May 20, 2002.

The Price of Things

- PER POUND TO GET TO LOW EARTH ORBIT (LEO)
  - Space Shuttle Cost (60 klbs) $7k - $12k
  - Boeing Delta IV (20-50 klbs) $3k - $7k
  - Boeing Delta II (6-13 klbs) $5k - $7k
  - ILS Proton (45 klbs) $2k - $2.5k
  - Space X Falcon I (1.5 klbs)-estimated $4k
  - Space X Falcon V (11 klbs)-estimated $1k
- PER PERSON
  - Soyuz to ISS $14M – $20M
  - Deposit on Sub-Orbital Flight $98 – $200k
  - Fly to the South Pole $33k
  - 20 Zero-G flights in a 727 $3k
  - HALO jump at 30k ft $3k

Short Term Space Tourism Prospects







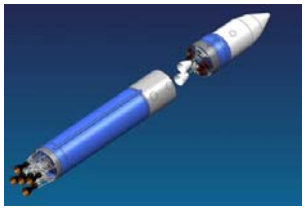
SpaceShipOne and The X-Prize

The Envisioned Future

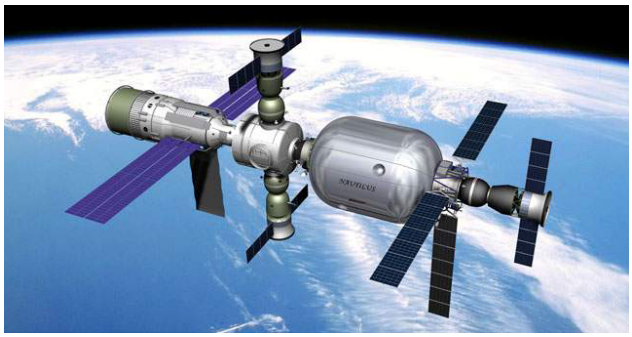
DARPA Responsive Access, Small Cargo, Affordable Launch (RASCAL)

- Defense Advanced Research Projects Agency (DARPA)
- Reusable airplane-like first stage
- Expendable second stage
- First stage could be heritage aircraft or new design
- First stage (MPV) will utilize MIPCC Propulsion
- Second stage is all-rocket/hybrid propulsion
- Very small payloads in the 100-300 lbs. range
- Required mission turnaround time of 24 hours
- Phase-1 Winners:
  - Coleman Research Corp.
  - Northrop Grumman Corp.
  - Pioneer Rocketplane
  - Space Launch Corp.
  - Space Access LLC
  - Delta Velocity
- Phase-2 Winner:
  - Space Launch Corp.

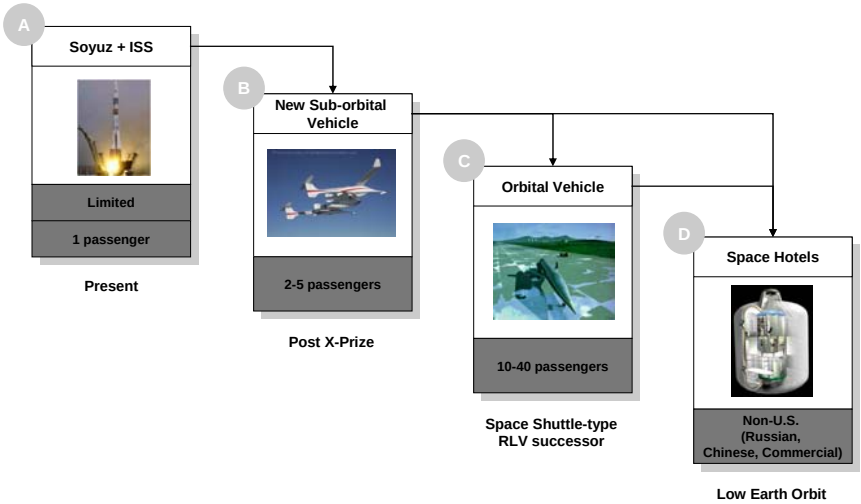
Future Cargo Transportation Example: Falcon I by SpaceX



Future Infrastructure Example: Nautilus by Bigelow Aerospace



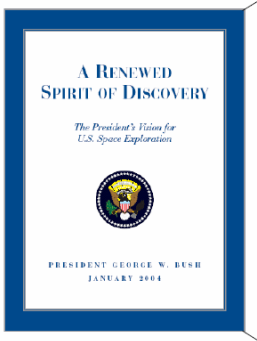

Possible Paths to Tourism



United States Vision for Space Exploration

U.S. President's Vision for Space Exploration

THE FUNDAMENTAL GOAL OF THIS VISION IS TO ADVANCE U.S. SCIENTIFIC, SECURITY, AND ECONOMIC INTEREST THROUGH A ROBUST SPACE EXPLORATION PROGRAM



Implement a sustained and affordable human and robotic program to explore the solar system and beyond

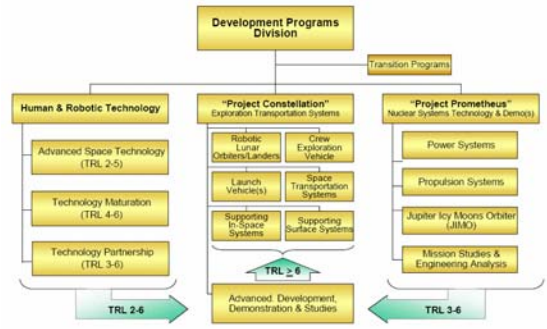
Extend human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations;

Develop the innovative technologies, knowledge, and infrastructures both to explore and to support decisions about the destinations for human exploration; and

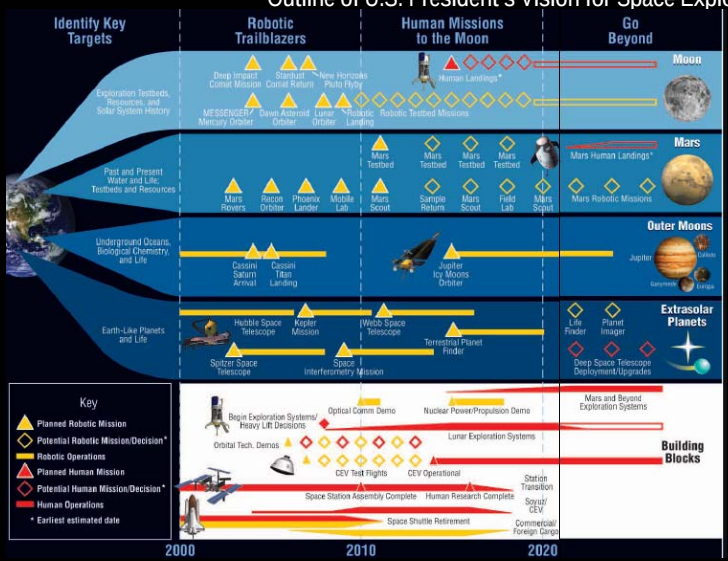
Promote international and commercial participation in exploration to further U.S. scientific, security, and economic interests.

Characteristics of President's Vision for Space Exploration

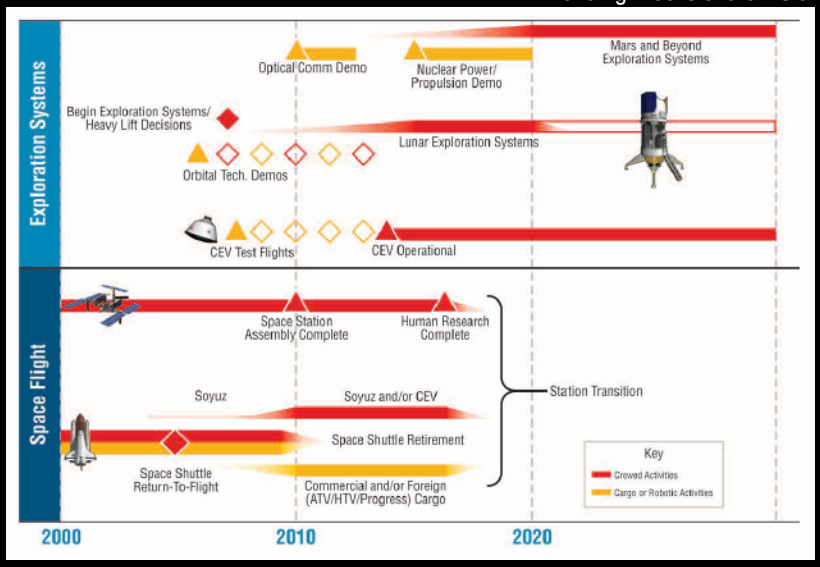
- Space Shuttle to complete International Space Station (ISS) only
- Focus research activity on human and robotic technologies
- Lunar robotic spacecraft with possible sample return
- Conduct the first extended human expedition to the lunar surface as early as 2015, but no later than the year 2020
- Develop new crew exploration vehicle to provide crew transportation for missions beyond low Earth orbit, test flights no later than 2014



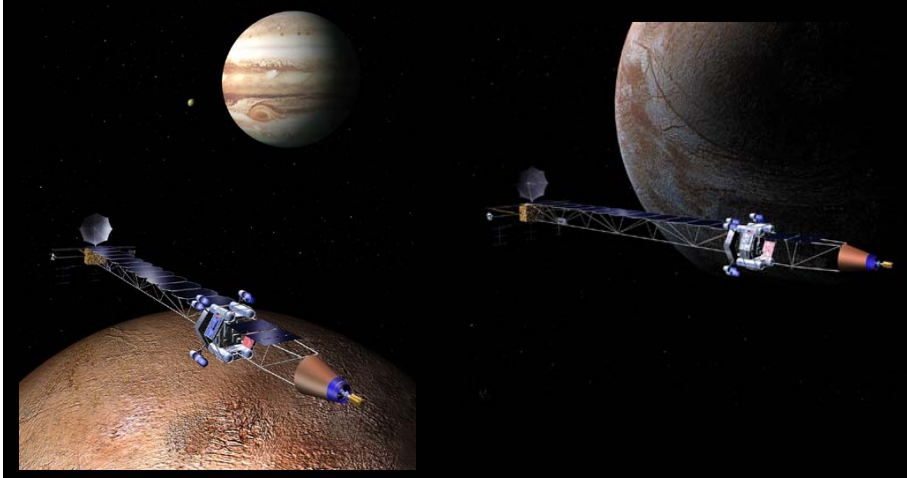
Outline of U.S. President's Vision for Space Exploration



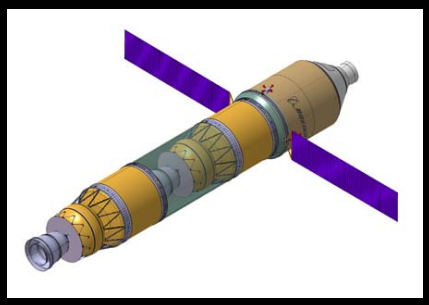
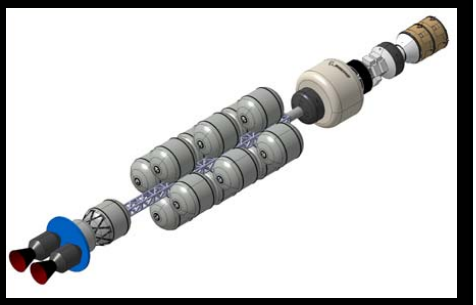
Building Blocks of the Vision

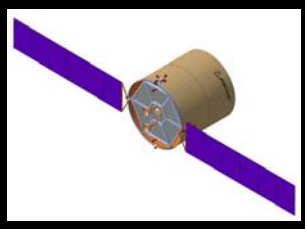


Jupiter Icy Moons Orbiter (JIMO)

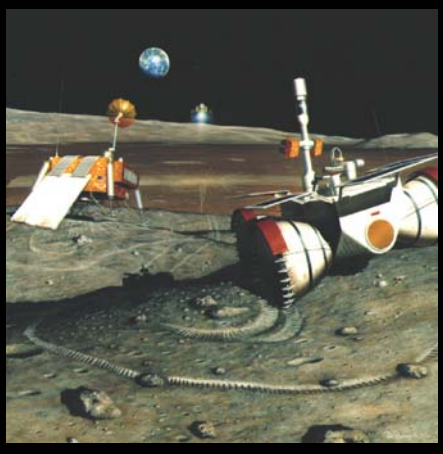


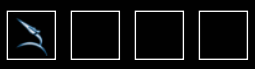
Crew Exploration System (Project Constellation)


Human and Robotic Technology



Observations

Government-Based Developments

- NASA's Vision for Space Exploration to be full-scale return to the Moon program with Mars follow-on
- Commercial potential (spin-offs and potential commercial service categories) of new Vision still to be determined
  - **How many pieces of the architecture required to go back to the Moon will be acquired directly from commercial providers versus developed in the traditional manner?**
- Space Shuttle is unlikely to fly again until 2005, and only to service space station
  - No U.S. program to actually replace the Shuttle has been initiated
  - Alternate Access to Space Station program no longer active
  - U.S.-derived manned space launch capability will rely on development of Crew Exploration Vehicle (CEV) to meet goals of new Vision for Space Exploration
  - CEV may most likely be either a capsule or lifting body on an expendable rocket booster
- Over the past 5 years, numerous government RLV-programs have been cancelled
  - X-33, X-34, SLI (redirected), new rocket engine development efforts
  - Full-scale RLV estimated at $15-$20B to develop
- Airbreathing / hypersonic space access vehicles remain 10-15+ years off
  - RBCC, TBCC, DMRS systems still of interest and receiving some funding, mainly through military
  - 2nd successful Hyper-X (X-43A) scramjet flight test in late 2004
  - First operational scramjet system on missiles
- NASA Centennial Challenges may fund several small scale prizes starting in FY2005 ($10M budget in 2005)
  - Four types of challenges
  - Flagship: 1-2 / year at $10-40M each, major private space mission
  - Keystone: 3-5 / year at $250K-3M each, subsystem development
  - Alliance: 2-4 / year at $100-250K each, NASA provides prize purse, others administer prize
  - Quest: Up to $1M / year, encourage science/technology/engineering/math careers

United States Recent Relevant Government Legislation

- United States HR 5382 (The Commercial Space Launch Amendments Act)
- Effect
  - Concerns the commercial space flight industry
  - Gives United States Federal Aviation Administration (FAA) unlimited authority to regulate new rockets to ensure that they do not harm anyone on the ground and to ensure that the industry is learning from any failures
  - Gives FAA additional authority after 8 years by which time the industry should be less experimental
  - Allows FAA AST to regulate only specific matters that have caused actual problems for passenger/crew safety for the first 8 years
- Current Status
  - Approved by the House of Representatives in 2004
  - Waiting to be go into the United States Senate in extra session within the next few weeks
  - If not passed by Senate, bill would have to restart journey back in House next year
  - HR 5382 is the latest compromise version of HR 3752, which in turn started out life as HR 3245

Commercial Developments

- Multiple start-up companies competing for small-satellite launch market (payloads from 100-2,000 lbs) and or sub-orbital tourism market in a post X-Prize environment
  - Initiatives from non-traditional aerospace funding sources
  - Incentives from various government programs (DARPA RASCAL, DARPA FALCON)
  - Organizations include: Virgin Galactic (Richard Branson of Virgin), SpaceX (Elon Musk from Paypal), Blue Origin (Jeff Bezos of Amazon.com), SpaceDev, Xcor, Microcosm, Armadillo Aerospace (John Carmack of id Software), X-Prize Cup (X-Prize Foundation)
- Initial development of commercial inflatable habitats
  - Bigelow Aerospace (Robert Bigelow)
- On-orbit commercial satellite servicing
  - Orbital Recovery Corporation (Walt Anderson)
- Reduced gravity flights
  - Zero Gravity Corporation (Peter Diamandis)
- New $50 million “America’s Space Prize”
  - A spacecraft capable of taking a crew of no fewer than five people to an altitude of 400 kilometers and complete two orbits of the Earth at that altitude
  - Have to repeat that accomplishment within 60 days
  - First flight must demonstrate only the ability to carry five crew members, the winner will have to take at least five people up on the second flight
  - Must be accomplished by 10 January 2010
  - No more than 20 percent of the spacecraft’s hardware can be expendable
  - It must also demonstrate the ability to dock with Bigelow Aerospace’s inflatable space habitat and be able to stay docked in orbit for up to six months

Status and Future of Space Commercialization

- Sustainable space **exploration** will only occur through **commercialization**
  - Higher flight rates, larger traffic will be required for such sustainability
- Space tourism can be seen as the only possible large-scale market for launch services (could possibly include Space Solar Power as well)
  - The killer application for space access that in the 1990s was commercial LEO satellites is now hoped to be space tourism
  - Waves of different commercial space activities can be seen to occur
  - In the 1990s different launch vehicle companies (Beal Aerospace, Rotary Rocket) and market assumptions (vast market of LEO commercial satellites)
- Current commercial cargo demand not very elastic and not growing rapidly
- Is there a first mover advantage or how many firms have to fail for innovation to occur?
  - First-mover advantage: A sometimes insurmountable advantage gained by the first significant company to move into a new market
  - Multiple efforts by a diverse set of companies and organizations (as is currently the case) in various areas of space transportation and infrastructure